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IV. *An Account, by Mr. John Eames, F. R. S. of a Book entitled, TRAITE PHYSIQUE ET HISTORIQUE DE L'AURORE BOREALE, Par Mr. DE MAIRAN. Suite des Memoires de l'Academie Royale des Sciences, Année MDCCXXXI: Or, a Philosophical and Historical Treatise concerning the Aurora Borealis ; By Mr. De Mairan, being a Supplement to the Memoires of the Academy of Sciences for the Year 1731.*

THE frequent Appearances of the *Northern Lights* in several Parts of *Europe* and *America*, and the surprisingly beautiful *Phænomena* that have been observed in some of them, such as the *Rainbow-Colours*, *Canopy*, &c. have very justly engaged the Philosophers of the present Age in a Search after the Causes of them. Several Hypotheses have been invented and proposed by the Learned, in order to explain these things. Most of them suppose these *Phosphorus* like Appearances to proceed from certain *Effluvia*, either perspired out of our Earth, or at least passing through it. But our ingenious Author has thought of a Cause very distant, as well as very different from all these, *viz.* the Atmosphere of the Sun, which at some times shews itself under the Appearance of a Light, which he calls the *Zodiacal Light*, but at other times produces an *Aurora Borealis*.

*alis.* The Zodiacal Light is the purer unmixed Atmosphere of the Sun : But an *Aurora Borealis* is the Effect of the Solar Atmosphere, consequent upon its making a Descent into, and blending itself with the Atmosphere of our Earth, at certain Times and Seasons of the Year. But a more particular Account of this Matter will be given hereafter.

The learned Author of this Work has taken a great deal of Pains in compiling it. He has look'd over the Accounts of Meteors, from the fifth Century down to the present Time, in the Historical Part ; and has ranged them in very good Order, in regard of the several Returns of this *Phænomenon*, making such Remarks by the way, as serve to support his Solution of it in the Philosophical Part.

By a Return he does not mean barely a single Appearance, but a Series of them after a Cessation or Non-appearance for several Years. Thus he makes but twenty-two Returns from the Year 400 to 1716, while the several Appearances of these Lights from 1707 to 1710, after a ceasing to be seen for twenty Years, are reckoned but one Return.

Mr. *Mairan* hopes the learned World will take the whole Performance under their Consideration, and give their free Thoughts upon it.

The Work consists of five Sections; the first gives a short History of the Zodiacal Light. In the second he treats at large of the Atmosphere of the Earth; its Altitude, and the Height of the *Aurora Borealis* in it, and the Exclusion this Circumstance gives to some of the Causes, which have been already assign'd, of this *Phænomenon*. In the third he proposes the Cause, and accounts for the Formation

tion of this Appearance in general, and then descends to a Detail of the several Particulars, adding the Solution of each. The next Section is employed in relating the Historical Proofs of his Hypothesis concerning the *Northern Lights*, taken from the Records we have of several Appearances of those Lights, to be met with in ancient Authors, compared with those of the Zodiacal Light, their supposed Cause, and the Situation of the Earth in her annual Orbit at those times. The last Section consists of twenty-eight curious Questions concerning several other *Phænomena* of Nature, which the ingenious Theorist believes to have a Dependence upon his new Hypothesis, and explicable by it.

But a more particular Account of these Matters may justly be expected.

Mr. *Mairan* begins the whole with laying before the Reader a short View of his Hypothesis concerning the Nature of an *Aurora Borealis*, defining his Terms as he goes along.

The *Aurora Borealis*, says he, is a luminous *Phænomenon*, so called from the Place of its Appearance, usually in the Northern Parts of the Heavens, and with a Light near the Horizon, resembling that of the Morning Dawn. This Name is supposed to be first given it by Mr. *Gassendi*, but it appears otherwise, from a Place in his Animadversions on *Diogenes*, quoted by Mr. *Mairan*.

The Cause of an *Aurora Borealis*, in general, he takes to be a Light called the Zodiacal Light, which is in reality nothing else but the Atmosphere of the Sun spread on each Side of him along the Zodiack, in the Form of a Pyramid. This sometimes is extended

tended to such a Length as to reach beyond the annual Orbit of our Earth, and in these Circumstances sometimes to blend itself with our Atmosphere, and being of an Heterogeneous Nature, produces the several Appearances which are observed in, and usually compose the *Northern Lights*. This he undertakes to explain, and prove more largely, in the sequel of the Work.

A Discourse upon the Nature of the *Zodiacal Light*, or Sun's Atmosphere, and the Matter of which it consists, is the Subject of the third Chapter. That it is very different from the Ambient *Æther*, he says is evident, in that the *Æther* reflects none of the Light of the Sun, is extremely rare, and altogether imperceptible. Whether the *Zodiacal Light* of the Solar Atmosphere be any Emanation from the Body of the Sun, a Species of Effervescence, or Depuration of its grosser Parts, an Amass of Heterogeneous Parts diffused in the *Æther*, that meeting from all Parts, tend towards the Sun, &c. he will not undertake to determine.

It is enough for his Purpose, that it is of a luminous Nature, whether in itself, or because strongly illuminated by the Rays of the Sun, whose Body it environs. He does not deny but that it may be also of an inflammable Nature, nay actual Flame or Fire, though very fine and rare.

He observes, that the Form in which the Atmosphere of the Sun is commonly seen in total Eclipses of the Sun, is Round, though sometimes Conical, of which he gives us a Figure.

At all other times it most usually presents itself to us in the Form of a lucid Pyramid, or Lance, lying oblique

oblique to the Horizon, along the Zodiac, and for that reason call'd by the late Mr. *Cassini* the *Zodiacal Light*. Mr. *J. Childrey* in his History of the Natural and Artificial Rarities of *England*, describes it thus. There is another thing which I must needs recommend to the Observation of Mathematical Men, which is, that in *February*, and for a little before, and a little after that Month, as I have observed several Years together about Six in the Evening, when the Twilight has almost departed the Horizon, you shall see a plainly discoverable Way of the Twilight, striking up towards the *Pleiades*, and seeming almost to touch them. It is to be observed any clear Night, but it is best seen *illumi Nocte*. There is no such Way to be observ'd at any other Time of the Year, that I can perceive, nor any other Way at that time to be perceived darting up elsewhere ; and I believe it has been, and will be constantly visible at that Time of the Year. But what the Cause of it in Nature should be, I cannot yet imagine, but leave it to farther Enquiry.

Upon a farther and closer Enquiry, and Consideration of this Matter, the ingenious Author, Mr. *Mairan*, tells us, he takes it to be the Solar Atmosphere, and therefore treats at large of the Reality, Visibility and Antiquity of this Light.

I beg leave to transcribe the Accounts of the same, given in by the Reverend Dr. *Derham*, Canon of *Windſor*. He informs us, that about a Quarter of an Hour after Sun-set, *April 3, 1707*, he perceived in the Western Parts of the Heavens a long slender Pyramidal Appearance, perpendicular to the Horizon. The Base of this Pyramid he judg'd to be

the Sun, then below the Horizon. Its *Apex* reached fifteen or twenty Degrees above the Horizon: It was throughout of a rusty red Colour, at first pretty vivid and strong, but the Top part much fainter than the Bottom nearer the Horizon. He did not remember he ever saw any thing like it, except the white Pyramidal Glade, which is now entitled by the Name of the *Aurora Borealis*, that being like it except in Colour and Length. Again, on the 20th of *March*, 1718, in the Evening, he espied a very odd Sort of Light in the Constellation of *Taurus*. This Glade of Light had the same Motion that the Heavens had, and was much like the Tail of a Comet, but pointed at the upper End. This Light, I doubt not, is such as Dr. *Childrey* first observed in *England*, and *Cassini* and others afterwards in *France*.

Mr. *Mairan* proceeds to give an Account of the true Figure, Extent, Situation, &c. of this Light, or Atmosphere of the Sun. Its true Figure he judges, with Mr. *Fatio*, to be lenticular, and gives a Projection of it upon the Plane of the Sun's Equator, the Eye being supposed in the Axis of the Sun produced through his South Pole at such a Distance as makes the Solar Atmosphere appear under the Angle of forty-five Degrees. In it you have a View of the Nodes, Poles, Limits, Declination and Extent, passing through and beyond the Orbits of *Mercury* and *Venus*, and in some Parts beyond the *Orbis Magnus*. This last Article of its Extent he demonstrates from several Observations of the Elongations of the Apex of this Pyramid from the Centre of the Sun. This has been found to be sometimes double that of *Venus*, and other times 90 Deg. and once or twice above

100, whereas an Elongation of 90 Deg. gives the Distance of the *Apex* from the Sun equal to that of the Earth at the time of Observation.

This Section is closed with an Account of the Changes, both real and apparent, to which the *Zodiacal Light*, or Solar Atmosphere is liable Its Length has been for some time upon the Increase, afterwards in a diminishing Condition, and has been altered so much in the Compass of thirty-seven Months, as to have been 30 Deg. longer at one time than at another. The Changes in Luminousness, Density and Transparency, has likewise been found to be very considerable. Sometimes the *Zodiacal Light* has been so rare and weak as to be but just visible, afterwards for a long time not visible at all.

Hereupon our ingenious Author thinks proper to observe, that these Considerations may serve in some Measure to account for the Inconstancy of the *Aurora Borealis*, as also for their Non-appearance for some Years; since they owe their Original to, and have so close a Connexion with the *Zodiacal Light*, whose Appearance is so uncertain. Add to this the *Zodiacal Light*, as he afterwards shews, must not only be of a sufficient Length and Density, but the Earth must be in or near the Nodes, form'd by the Intersection of the Plane of the Sun's Equator with the Plane of the Ecliptick.

The second Section treats at large of the Altitude of our Atmosphere, and of that of the Region in it usually possess'd by the *Aurora Borealis*. Under this Head he discourses of the several Methods the Mathematicians have used to find the greatest Heights of the Air, such as the Duration of the Twilight, the Altitude of the *Mercury* in the Barometer, and



rejects them as insufficient for that Purpose ; the Atmosphere being much higher than what has been ever found by them, and consisting of a Fluid much finer than the gross or common Air, the Height of which last only is measurable by these ways.

Mr. *Mairan* therefore goes on to settle the Altitude of the *Northern Lights*, after another manner, founded upon several Observations made at very distant Places at the same time, and fixes some *Aurora Boreales* to be but one hundred Leagues, though others are no less than three hundred, and the far greater Number of them about two hundred Leagues above the Surface of the Earth.

Mr. *Cramer*, Professor of the Mathematicks at *Geneva*, computes the Height of the *Aurora Borealis*, seen at the same time at *Geneva* and *Montpellier*, Feb. 15th, 1730, to be  $\frac{111}{1000}$  of a Semidiameter of the Earth, i. e. about 160 Leagues.

Mr. *Meyer* has proposed in the Memoires of the Academy of *Petersburgh*, a very ingenious Method of finding the Height and Distance of a *Boreal Arc*, from any Observer, by a single Observation. Mr. *Mairon* applies this Method to such *Aurora Boreales* as were capable of it, and finds that the *Boreal Arcs* of several were no less than an hundred Leagues high.

It is on this account that in the next Chapter our Author considers some Solutions that have been offered to solve these Appearances of the *Northern Lights*, and sets them aside as insufficient, because they suppose Causes which have no Existence, or at least no Efficacy at so great a Height in the Atmosphere.

The next Section is the principal, and is engag'd in explaining the several particular Appearances of the *Lumen Boreale*, such as its Situation, ordinarily towards the *North*, declining a little towards the *West*; its dark, dusky, circular Basis, surmounted sometimes with one or more luminous Arcs; from behind which Columns, or Streams of Light, seem to issue either perpendicularly or concentric with the Arcs; add to these the Rainbow-Colours, Flashes, Vibrations, and in the last Place, a Glory, Canopy, or *Corona*, form'd by a Concourse of the Rays of the Matter of this *Phænomenon*, near the Zenith of the Place.

Mr. *Mairan* premises an Investigation of the *Locus*, or Limit of the Attractive Forces of the Sun and Earth, so that a Particle of Matter placed any where in it, will be equally attracted by both, or tend as much towards the Earth as it does towards the Sun. He finds, that if in a Line connecting the Centres of the Sun and Earth, a Point be taken at the Distance of about 43 Semidiameters of the Earth from her Centre, that Point will be in this Limit, so that a Particle placed there, will not gravitate either towards the Sun or Earth, but remain in *Æquilibrio*, the equal and contrary Forces of the Sun and Earth destroying each other. The Use he makes of this is to shew, that an *Aurora Borealis* may possibly be formed by a Descent of the *Zodiacal Matter*, lying between this Point of *Æquilibrium* and the Earth; tho' it does not reach so far as to involve the Earth itself. But the *Aurora* in this Case will be an incomplete and particular one.

The *Lumen Boreale* ordinarily appears in the Northern Parts of the Heavens, because tho' the whole Atmosphere of the Earth be involved in the *Zodiacal Matter* (or Solar Atmosphere) yet 'tis thrown off both ways, from the Equatorial towards the Polar Regions.

This is owing to a double Cause, the first is the centrifugal Force, arising from the diurnal Motion of the Earth, which being greatest at the Equator (and gradually lessening as you approach the Poles, where it vanishes) makes greatest Opposition there, and not only hinders the Entrance of the *Zodiacal Matter* into the Earth's Atmosphere, near the Equatorial Region, but turns it aside into a Course towards each Pole; and the Author does not question but an *Aurora Australis* might be seen at proper times in the Southern Temperate Zone, just as an *Aurora Borealis* is in ours, which is Northern, attended with similar *Phænomena*, were there but attentive Observers.

The second Cause is the progressive Motion of the Earth in its annual Orbit near one half of the Year with the *North Pole* foremost, and in the other half with the *South Pole*, moving thro' the *Zodiacal Matter*.

The natural Consequence of which will be a heaping up of Matter, more on the Polar Regions than the Equatorial or Temperate, and this accounts in part for the Declination of the Centre of the luminous Arcs, sometimes near ten Degrees from the *Pole*; the Direction of this Motion of the Earth not coinciding with the Direction of the Axis of the Earth, at those times.

The dark Arcular Segment next the Horizon appearing like a heavy black Cloud, or Mist, is form'd out of the densest and specifically heaviest Parts of the *Zodiacal Matter*, which in their Descent must sink deepest into the Earth's Atmosphere, and are least inflammable in their Nature, while the rarer and lighter Parts, which are more inflammable and luminous, if not actually inflam'd, form the Arc or Arcs that lie above the dark Segment. The ingenious Author speaks of a *Fort de l'incendie*, a Place where the *Zodiacal Matter* collected together, and moving or passing thro' it, is actually turn'd into Flame. Thus long Trains of descending *Zodiacal Matter* arriving in their Descent at this Place, being kindled, or at least reflecting the Light of that *Incendium*, produce the several Columns or Streams of Light that appear above, or behind the obscure circular Base, or luminous Arches.

The Breaks that are sometimes visible in these Arches, are occasioned by the Descent and Passage of several discontinued Trains and Flakes of the denser and least inflammable Parts of the *Zodiacal Matter*, between the Eye of the Spectator and the luminous Arch.

The various Colours arise from a Separation of the Rays of Light from each other, either by a sort of Filtration in passing thro' Mediums of different Densities, or by the Divergence of the differently refrangible and coloured Rays (or rather from the different Celerities of those Rays, as the Author says he has explained more at large in another Place) after the manner that the Colours are formed in Clouds near the Horizon about the rising or setting Sun.

To

To conclude, the Canopy in a compleat *Aurora Borealis* he looks upon to be an Object purely optical, a simple Appearance arising from a singular Distribution of several perpendicular Columns, or Trains of *Zodiacal Matter*, as he explains more at large in two Figures. This Exactness and Regularity in the Distribution makes it an uncommon *Phænomenon*; so that among an hundred *Auroræ Boreales* that have been observed, he has met with but three attended with a *Corona*.

What remains, is only to take Notice of some of the Queries which relate to several Appearances in Nature, that seem to be explicable by our Author's Hypotheses of a Solar Atmosphere, such as the *Nebulæ*, or lucid Spots observ'd among the fix'd Stars, the Spots in the Sun, the Atmosphere and Tails of Comets, &c.

The *Nebulæ* are certain luminary Spots or Patches, which discover themselves only by the Telescope, and appear to the naked Eye like small fix'd Stars. They are fix in Number, and are accurately described in *Philosoph. Transact.* N° 347. Some of them have no Sign of a Star in the middle of them, and are properly *Nebulæ*, others have, and then are called *Nebulosæ*. They are look'd upon by some to be in reality nothing else but the Light coming from an immense great Space in the *Æther*, thro' which a lucid Medium is diffused, that shines with its own proper Lustre, making a perpetual uninterrupted Day, by no means owing to the Illumination of a central Body, or Star.

But Mr. *Mairan* seems to be of another Mind, and queries thus : Since the fix'd Stars are Bodies of the

the same Nature with our Sun, may not some of them have Atmospheres surrounding them so luminary and extended, as to become visible to us by a Light easily distinguishable from that of the central Body, and may not Atmospheres of others be so dense as well as luminous, and extended, as may suffice to obfuscate (to use the Author's Expression) the Light of the Star involved in it? Are not the *Nebulosæ* of the former Sort, and the *Nebulæ* of the latter? The lucid Spot in the *Cingulo Andromedæ*, which after *Hevelius* our Author continues to call a *Nebulosa*, has been found by the late Mr. *Cassini* to resemble the *Zodiacal Light* in some Circumstances, and by Mr. *Kirch* to have suffer'd some Changes appearing and disappearing by turns.

Mr. *Mairan* observes by the way, that this Spot was first discover'd, not by Mr. *Bullialdus* in 1660, as is commonly believed, but by Mr. *Simon Marius* in 1612, who fully describes it in the Preface to his *Mundus Fovialis*.

The luminous Space round the *Nebulosæ* of *Orion's Sword*, discover'd and described by Mr. *Hugens*, he takes to be an Assemblage, or Sum Total of the several Atmospheres of the Stars, plainly visible within that Space, and it may be of some others that are concealed from our View. The Irregularity of the Shape is no Difficulty to him, it arising from the different, and to us seemingly irregular Positions of their Atmospheres. He adds, as a Confirmation of his Hypothesis, that the Brightness and very Figure of this Space has suffered some Alterations since Mr. *Hugens's* Time. That one of the Stars delineated by Mr. *Hugens* without any surrounding Light, has

since been found to have a pale Light like an Atmosphere surrounding it.

*Quer. 2.* Is not the Solar Atmosphere liable to frequent Fermentations, and subsequent Precipitations of its grosser Parts towards the Surface of the Sun? and are not the different Degrees of Brightness and Transparency owing hereunto? since the Changes in our Air, or Atmosphere, are not sufficient to account for the Non-appearance of the *Zodiacal Light* in some convenient Seasons, and clear Nights.

*Quer. 3.* May not the Spots, so often of late observed in the Surface of the Sun, be owing to these Precipitations of the grosser Parts of the *Zodiacal Light*, since there seems to be some Analogy or Correspondence between the Frequency, Cessation and Returns of these Spots, with the Cessation, Returns and Apparitions of the *Zodiacal Light*?

*Quer. 4.* Are not the Inferior Planets, *Mercury* and *Venus*, almost always immersed in the *Zodiacal Matter*? and may not that be one Reason why 'tis so difficult to observe Spots in them? May not a Change, the Density, or Magnitude of the Solar Atmosphere, be one Reason why the Astronomers at *Paris* have not been able to observe those Spots in the Disk of *Venus* that have been taken Notice of, and described by Mr. *Bianchini* at *Rome*, a little before, since the Telescopes at *Paris* were of equal Length and Goodness?

*Quer.*

*Quer. 20.* May not the Augmentation of the Quantity of Matter in the Earth and Inferior Planets, by the continued Accumulation of the *Zodiacal Matter* on their Surfaces during a long Course of several Ages, produce, among other things, some Alteration in their Periodical Motions?

*Quer. 21, &c.* May not the Atmosphere and Tail of a Comet be owing to the *Zodiacal Matter*, which the Comet during its Passage through the Atmosphere of the Sun intercepts, and afterwards carries away with it, in its Ascent from the Sun?

*Quer. 28.* Is not the Earth safe enough from all Danger of any Inundation, much more of an Universal Deluge, tho' it should pass thro' the Atmosphere, or Tail of a Comet? since the Effects of such a Passage can only be an *Aurora Borealis*, whose Matter is not at all of a watry vaporous Nature? A Conflagration rather than an Inundation might have been imagined to be the natural Consequence, but Experience informs us, that if this Hypothesis be admitted as genuine, that our Earth has been entirely plunged in this *Zodiacal Matter* without any sensible Heat attending it.